CROPS AND CONSUMPTIVE USE

Consumptive use, often called evapotranspiration, is the amount of water used by the vegetative growth in transpiration and building of plant tissue and that evaporated from adjacent soil or intercepted precipitation on the plant foliage.

The stage of a crop's growth has a considerable influence on its consumptive use rate. Annual crops have three distinct stages of growth. These are: (1) emergence and development of complete vegetative cover during which time consumptive use rate increases rapidly from a low value and approaches its maximum; (2) the period of maximum vegetative cover during which time the consumptive use rate may be near or at its maximum if abundant soil moisture is available; and (3) crop maturation where the consumptive use rate begins to decrease. During the latter period, the plant becomes the limiting factor in the transpiration rate.

Consumptive use values were determined using a modified Penman equation and crop growth coefficient curves. Input data for the modified Penman equation are temperature, humidity, wind, bright sunshine hours, latitude, and mean sea level elevation.

Details on this method can be found in the Food and Agriculture Organization of the United Nations Irrigation and Drainage Paper 24, "Guidelines for Predicting Crop Water Requirements."

The state is divided into four areas called irrigation climatic areas for the purpose of calculating consumptive use. The areas are shown on Figure 3.1.

Effective rainfalls were determined by the following procedure:

1. Statistical analyses were made of rainfall for each of the months April through October plus the total growing season.

2. Effective rainfall for the individual month was based on the analysis for that month and was related to monthly consumptive use and the net irrigation application to arrive at effective rainfall for the month. The value for a normal year represents a 50 percent chance of recurrence and the value for a dry year represents an 80 percent chance of recurrence. Details on the method for relating rainfall to monthly consumptive use and the net irrigation application can be found in Soil Conservation Service Technical Release No. 21, "Irrigation Water Requirements."

3. The same procedure as outlined in Step 2 was repeated for the seasonal values of rainfall to determine seasonal effective rainfall.

Because there is greater variability in monthly rainfall amounts than there is in seasonal rainfall amounts, the seasonal effective rainfall is greater than the sum of the individual monthly effective rainfalls.

Net irrigation requirements are shown in Tables 3.1 and 3.2 and are adjusted for the effect of effective rainfall expected during a normal year (50 percent chance) and a dry year (80 percent chance). Carry-over soil moisture is moisture available in the soil usually above the 50 percent available water holding capacity at the beginning of the growing season. This carryover soil moisture is used to delay and reduce the net irrigation.

There is a greater chance for rain to fall on a soil at a time when it is capable of holding water if the available water holding capacity is high and irrigation frequency is long. This situation occurs when applying near the maximum allowable net application. Hence, when the net application of irrigation water is large, a larger percentage of the total rainfall will be effective. For net irrigation applications other than 3 inches or 1½ inches, the effective rainfall shown on Table 3.2 must be multiplied by the correction factor given below:

Net Depth of Application	.75	1.0	1.5	2.0	2.5	3.0	4.0	5.0
Factor	.72	.77	.86	.93	.97	1.00	1.02	1.04

When the amount of effective rainfall is reduced because of using less than a 3-inch net depth of application, the net amount of irrigation water required must be increased accordingly. Likewise, if the net depth of application is more than 3 inches, the net amount of irrigation water required may be decreased by the same amount.

To determine the amount of irrigation water that should be applied each month, it is necessary to consider the following:

1. The amount of water necessary to fill the root zone to field capacity.

2. The amount to be added to each month's needs because of losses in application. This will vary with soils, the irrigation system and field efficiencies.

3. The amount applied near the end of the use season may be increased an amount equal to the stored moisture which has been depleted to provide for a greater chance of leaching before the next growing season.

4. The time of water application will precede the use period by a period depending on the amount of available water the root zone of the crop will hold.

The net water to be replaced during a normal irrigation is usually the water above the 50 percent level of available moisture holding capacity for the irrigation root depth. This can be determined by referring to Table 3.4 to find the irrigation depth of the particular crop and Chapter 2 for the available water holding capacity. The AWC is

multiplied by the percent depletion, usually not more than 50 percent, to find the net amount of water to be replaced at a normal irrigation. Additional water must be added to compensate for evaporation losses, uneven distribution, and interception by foliage.

Example:

Given: Soil - Banks (Irrigation Group VIIIA)
Crop - corn, in later part of July

From Table 3.4, Page 3-25, the depth to irrigate corn at maximum root growth is 4.0 feet.

From Page 2-42, the available water capacity of Banks to a 4.0 foot depth is 4.5 inches.

The net water to be replaced would be between the 50 percent and the 90 percent available levels, leaving some water available to the crops during the irrigation period and some capacity after irrigation to accommodate a rain. The 90% - 50% = 40% x 4.5 inches = 1.8 inches net irrigation application. Using a center pivot system, Table 5.11, Page 5-27, shows a 75 percent efficiency. Thus, a gross irrigation application would be 1.8 inches ÷ .75 = 2.4 inches.

The irrigation frequency in the southeastern part of the state or Climatic Area II under design conditions is the net irrigation application divided by the design period daily use, as found in Table 3.3, Page 3-23 (1.8 ÷ 0.30 = 6.0 days).

To find the estimated seasonal and monthly crop use, since the application rate is not 3.0 inches or 1.5 inches as calculated in Tables 3.1 and 3.2, use Table 3.2, Page 3-15, and adjust by a factor of 0.90 for 1.8 inch application as shown in the middle of Page 3-2.

Crop: Corn, May 16 - September 23
Net application - 1.8 inches
Carryover soil moisture - 2.25 inches

Month	Consumptive Use	Effective Rainfall Normal Year	Adjusted Rainfall	Adjusted Net Irrigation
May	1.75	0.81	0.73	----
June	5.01	2.52	2.27	1.51
July	8.21	2.33	2.10	6.11
August	7.27	2.03	1.83	5.44
September	2.96	1.02	0.92	2.04
Season	25.20	9.53	8.58	15.10

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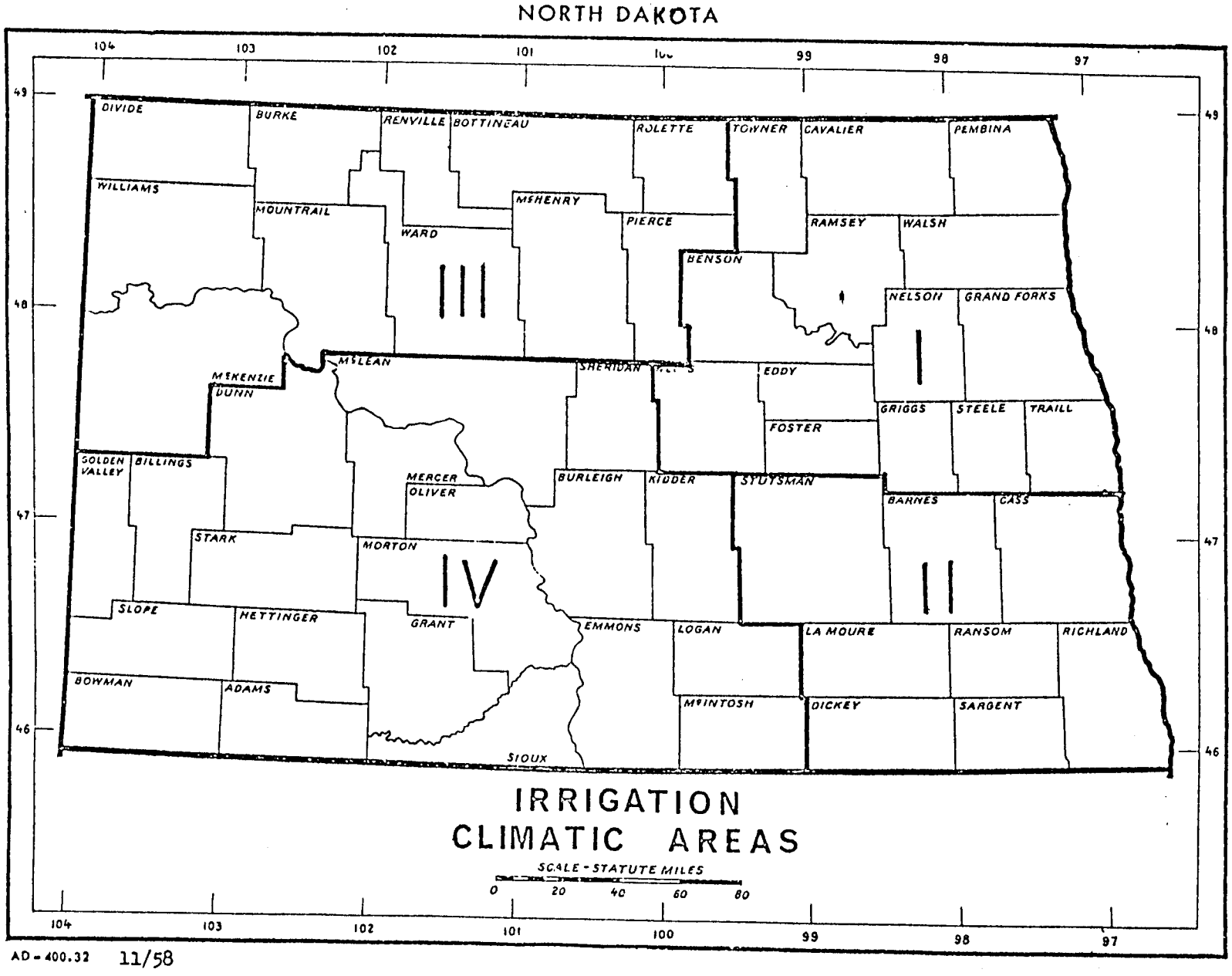

Figure 3.1

TABLE 3.1

ESTIMATED SEASONAL AND MONTHLY CONSUMPTIVE USE

Climatic Area I

Carryover Soil Moisture 2.0" - Net Irrigation Application 1.5"

Month	Consumptive Use (Inches)	Effective Rainfall (Inches)		Net Irrigation (Inches)	
		Normal Year	Dry Year	Normal Year	Dry Year
Crop: Alfalfa		Average Growing Season: 5/1 - 10/8			
April	--	--	--	--	--
May	4.59	1.38	0.77	1.21	1.82
June	5.95	2.09	1.38	3.86	4.57
July	7.34	1.88	1.08	5.46	6.26
August	6.41	1.27	0.77	5.14	5.64
September	3.53	0.73	0.30	2.80	3.23
October	0.56	0.20	0.07	0.36	0.49
Season	28.38	8.50	6.61	17.88	19.77
Crop: Corn		Average Growing Season: 5/21 - 9/20			
April	--	--	--	--	--
May	1.07	0.41	0.20	0.00	0.00
June	4.48	1.94	1.31	1.20	2.04
July	8.12	1.95	1.12	6.17	7.00
August	7.11	1.43	0.82	5.68	6.29
September	2.43	0.48	0.20	1.95	2.23
October	--	--	--	--	--
Season	23.21	6.85	5.38	14.36	15.83
Crop: Sugar Beets		Average Growing Season: 5/20 - 10/1			
April	--	--	--	--	--
May	0.61	0.38	0.19	0.00	0.00
June	3.08	1.81	1.20	0.00	0.30
July	8.36	1.96	1.12	5.90	7.24
August	7.81	1.38	0.82	6.43	6.99
September	4.37	0.76	0.33	3.61	4.04
October	--	--	--	--	--
Season	24.23	7.13	5.48	15.10	16.75
Crop: Small Grain		Average Growing Season: 5/1 - 8/8			
April	--	--	--	--	--
May	3.12	1.31	0.70	0.00	0.42
June	7.42	2.28	1.52	4.95	5.90
July	7.26	1.85	1.08	5.41	6.18
August	0.81	0.26	0.15	0.59	0.70
September	--	--	--	--	--
October	--	--	--	--	--
Season	18.61	6.23	4.93	10.38	11.68

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CONSUMPTIVE USE = ET

TABLE 3.1

ESTIMATED SEASONAL AND MONTHLY CONSUMPTIVE USE

Climatic Area I

Carryover Soil Moisture 2.0" - Net Irrigation Application 1.5"

Month	Consumptive Use (Inches)	Effective Rainfall (Inches)		Net Irrigation (Inches)	
		Normal Year	Dry Year	Normal Year	Dry Year
Crop: Potatoes		Average Growing Season: 6/4 - 9/15			
April	--	--	--	--	--
May	--	--	--	--	--
June	3.69	1.65	1.08	0.04	0.61
July	7.42	1.89	1.09	5.53	6.33
August	7.25	1.36	0.83	5.89	6.42
September	2.09	0.34	0.16	1.75	1.93
October	--	--	--	--	--
Season	20.45	5.81	4.57	12.64	13.88
Crop: Field Beans		Average Growing Season: 6/4 - 9/15			
April	--	--	--	--	--
May	--	--	--	--	--
June	2.75	1.55	1.02	0.00	0.00
July	5.86	1.72	0.97	3.34	4.62
August	6.69	1.30	0.77	5.39	5.92
September	2.17	0.34	0.14	1.83	2.03
October	--	--	--	--	--
Season	17.46	5.49	4.22	9.97	11.24
Crop: Grass		Average Growing Season: 5/1 - 9/30			
April	--	--	--	--	--
May	3.24	1.29	0.70	0.00	0.54
June	5.69	2.10	1.38	3.54	4.31
July	7.19	1.87	1.08	5.32	6.11
August	6.12	1.26	0.77	4.86	5.35
September	2.78	0.69	0.29	2.09	2.49
October	--	--	--	--	--
Season	25.02	8.11	6.31	14.91	16.71
Crop:		Average Growing Season:			
April					
May					
June					
July					
August					
September					
October					
Season					

TABLE 3.1

ESTIMATED SEASONAL AND MONTHLY CONSUMPTIVE USE

Climatic Area II

Carryover Soil Moisture 2.0" - Net Irrigation Application 1.5"

Month	Consumptive Use (Inches)	Effective Rainfall (Inches)		Net Irrigation (Inches)	
		Normal Year	Dry Year	Normal Year	Dry Year
Crop: Alfalfa		Average Growing Season: 4/15 - 10/15			
April	1.71	0.54	0.28	0.00	0.00
May	5.20	1.65	1.05	2.72	3.58
June	6.42	2.36	1.33	4.06	5.09
July	7.49	1.92	1.18	5.57	6.31
August	6.49	1.67	1.03	4.82	5.46
September	3.77	1.19	0.56	2.58	3.21
October	1.09	0.33	0.09	0.76	1.00
Season	32.17	10.22	8.19	19.95	21.98
Crop: Corn		Average Growing Season: 5/16 - 9/23			
April	--	--	--	--	--
May	1.75	0.70	0.44	0.00	0.00
June	5.01	2.17	1.25	1.89	3.07
July	8.21	2.00	1.23	6.21	6.98
August	7.27	1.75	1.10	5.52	6.17
September	2.96	0.88	0.36	2.08	2.60
October	--	--	--	--	--
Season	25.20	8.20	6.57	17.00	16.63
Crop: Sugar Beets		Average Growing Season: 5/15 - 10/1			
April	--	--	--	--	--
May	0.97	0.69	0.41	0.00	0.00
June	3.95	2.02	1.16	0.21	1.35
July	8.77	2.05	1.25	6.72	7.52
August	7.91	1.81	1.14	6.10	6.77
September	4.60	1.24	0.59	3.36	4.01
October	--	--	--	--	--
Season	26.20	8.37	6.76	15.83	17.44
Crop: Small Grain		Average Growing Season: 4/15 - 7/24			
April	2.86	0.59	0.30	0.27	0.56
May	5.59	1.69	1.06	3.90	4.53
June	7.86	2.53	1.48	5.33	6.38
July	3.89	1.24	0.74	2.65	3.15
August	--	--	--	--	--
September	--	--	--	--	--
October	--	--	--	--	--
Season	20.20	6.35	5.13	11.85	13.07

TABLE 3.1

ESTIMATED SEASONAL AND MONTHLY CONSUMPTIVE USE

Climatic Area II

Carryover Soil Moisture 2.0" - Net Irrigation Application 1.5"

Month	Consumptive Use (Inches)	Effective Rainfall (Inches)		Net Irrigation (Inches)	
		Normal Year	Dry Year	Normal Year	Dry Year
Crop: Potatoes		Average Growing Season: 5/30 - 9/1			
April	--	--	--	--	--
May	0.12	0.05	0.03	0.00	0.00
June	4.79	2.12	1.22	0.74	1.66
July	8.21	2.00	1.25	6.21	6.96
August	6.70	1.69	1.05	5.01	5.65
September	--	--	--	--	--
October	--	--	--	--	--
Season	19.82	6.35	5.17	11.47	12.65
Crop: Field Beans		Average Growing Season: 5/30 - 9/15			
April	--	--	--	--	--
May	0.09	0.05	0.03	0.00	0.00
June	3.38	1.96	1.14	0.00	0.30
July	6.30	1.81	1.11	3.95	5.19
August	6.77	1.69	1.05	5.08	5.72
September	2.27	0.57	0.26	1.70	2.01
October	--	--	--	--	--
Season	18.82	6.52	5.32	10.30	11.50
Crop: Grass		Average Growing Season: 4/15 - 10/15			
April	1.28	0.56	0.27	0.00	0.00
May	4.17	1.54	0.91	1.35	2.27
June	6.13	2.30	1.32	3.83	4.81
July	7.32	1.90	1.17	5.42	6.15
August	6.27	1.66	1.02	4.61	5.25
September	3.39	1.16	0.56	2.23	2.83
October	0.87	0.28	0.09	0.59	0.78
Season	29.44	10.01	8.02	17.43	19.42
Crop:		Average Growing Season:			
April					
May					
June					
July					
August					
September					
October					
Season					

TABLE 3.1

ESTIMATED SEASONAL AND MONTHLY CONSUMPTIVE USE

Climatic Area III

Carryover Soil Moisture 2.0" - Net Irrigation Application 1.5"

Month	Consumptive Use (Inches)	Effective Rainfall (Inches)		Net Irrigation (Inches)	
		Normal Year	Dry Year	Normal Year	Dry Year
Crop: Alfalfa		Average Growing Season: 5/1 - 10/8			
April	--	--	--	--	--
May	4.84	1.09	0.49	1.75	2.35
June	6.27	1.89	1.10	4.38	5.17
July	7.76	1.55	0.88	6.21	6.88
August	6.77	1.43	0.59	5.34	6.18
September	3.79	0.69	0.28	3.10	3.51
October	0.62	0.10	0.09	0.52	0.53
Season	30.05	7.47	5.85	20.58	22.20
Crop: Corn		Average Growing Season: 5/18 - 9/16			
April	--	--	--	--	--
May	1.45	0.36	0.15	0.00	0.00
June	4.94	1.73	1.00	2.30	2.51
July	8.66	1.63	0.90	7.03	7.76
August	7.37	1.51	0.65	5.86	6.72
September	2.09	0.34	0.14	1.75	1.95
October	--	--	--	--	--
Season	24.50	6.04	4.71	16.46	17.79
Crop: Sugar Beets		Average Growing Season: 5/20 - 10/1			
April	--	--	--	--	--
May	0.63	0.30	0.15	0.00	0.00
June	3.24	1.60	0.93	0.00	0.79
July	8.83	1.63	0.95	7.17	7.88
August	8.26	1.59	0.68	6.67	7.58
September	4.69	0.72	0.30	3.97	4.39
October	--	--	--	--	--
Season	25.65	6.42	5.02	17.23	18.63
Crop: Small Grain		Average Growing Season: 5/1 - 8/8			
April	--	--	--	--	--
May	3.29	1.01	0.46	0.28	0.83
June	7.83	2.05	1.24	5.78	6.59
July	7.67	1.54	0.89	6.13	6.78
August	0.68	0.28	0.09	0.40	0.59
September	--	--	--	--	--
October	--	--	--	--	--
Season	19.37	5.43	4.23	11.94	13.14

TABLE 3.1

ESTIMATED SEASONAL AND MONTHLY CONSUMPTIVE USE

Climatic Area III

Carryover Soil Moisture 2.0" - Net Irrigation Application 1.5"

Month	Consumptive Use (Inches)	Effective Rainfall (Inches)		Net Irrigation (Inches)	
		Normal Year	Dry Year	Normal Year	Dry Year
Crop: Potatoes		Average Growing Season: 6/2 - 9/15			
April	--	--	--	--	--
May	--	--	--	--	--
June	4.25	1.58	0.91	0.67	1.34
July	8.00	1.57	0.89	6.43	7.11
August	7.59	1.51	0.65	6.08	6.94
September	2.24	0.33	0.15	1.91	2.09
October	--	--	--	--	--
Season	22.08	5.34	4.21	14.74	15.87
Crop: Field Beans		Average Growing Season: 6/2 - 9/15			
April	--	--	--	--	--
May	--	--	--	--	--
June	3.12	1.50	0.88	0.00	0.24
July	6.35	1.43	0.80	4.54	5.55
August	7.07	1.48	0.63	5.59	6.44
September	2.24	0.33	0.15	1.91	2.09
October	--	--	--	--	--
Season	18.78	5.10	3.98	11.68	12.80
Crop: Grass		Average Growing Season: 5/1 - 10/8			
April	--	--	--	--	--
May	3.41	1.02	0.46	0.39	0.95
June	5.92	1.85	1.08	4.07	4.84
July	7.51	1.54	0.88	5.97	6.63
August	6.62	1.42	0.58	5.20	6.04
September	3.32	0.68	0.28	2.64	3.04
October	0.47	0.07	0.03	0.40	0.44
Season	27.25	7.34	5.70	17.91	19.55
Crop:		Average Growing Season:			
April					
May					
June					
July					
August					
September					
October					
Season					

TABLE 3.1

ESTIMATED SEASONAL AND MONTHLY CONSUMPTIVE USE

Climatic Area IV

Carryover Soil Moisture 2.0" - Net Irrigation Application 1.5"

Month	Consumptive Use (Inches)	Effective Rainfall (Inches)		Net Irrigation (Inches)	
		Normal Year	Dry Year	Normal Year	Dry Year
Crop: Alfalfa		Average Growing Season: 4/15 - 10/15			
April	1.77	0.31	0.19	0.00	0.00
May	5.35	1.27	0.65	3.54	4.28
June	6.50	2.17	1.42	4.33	5.08
July	7.92	1.51	0.67	6.41	7.25
August	7.29	1.16	0.51	6.13	6.78
September	4.15	0.65	0.28	3.50	3.87
October	1.29	0.15	0.06	1.14	1.23
Season	34.19	8.44	6.56	23.75	25.63
Crop: Corn		Average Growing Season: 5/18 - 9/22			
April	--	--	--	--	--
May	1.51	0.45	0.22	0.00	0.00
June	5.00	2.00	1.30	2.06	2.99
July	8.68	1.58	0.68	7.10	8.00
August	7.74	1.18	0.61	6.56	7.13
September	2.94	0.41	0.19	2.53	2.75
October	--	--	--	--	--
Season	25.87	6.39	5.05	17.48	18.82
Crop: Sugar Beets		Average Growing Season: 5/15 - 10/1			
April	--	--	--	--	--
May	0.98	0.54	0.26	0.00	0.00
June	4.00	1.89	1.23	0.55	1.49
July	9.27	1.61	0.71	7.66	8.56
August	8.42	1.22	0.54	7.20	7.88
September	5.05	0.68	0.29	4.37	4.76
October	--	--	--	--	--
Season	27.72	6.80	5.36	18.92	20.36
Crop: Small Grain		Average Growing Season: 4/15 - 7/24			
April	1.00	0.31	0.16	--	--
May	5.84	1.29	0.65	2.24	3.03
June	7.92	2.37	1.57	5.55	6.35
July	4.10	0.96	0.40	3.14	3.70
August	--	--	--	--	--
September	--	--	--	--	--
October	--	--	--	--	--
Season	18.76	5.55	4.36	11.21	12.40

TABLE 3.1

ESTIMATED SEASONAL AND MONTHLY CONSUMPTIVE USE

Climatic Area IV

Carryover Soil Moisture 2.0" - Net Irrigation Application 1.5"

Month	Consumptive Use (Inches)	Effective Rainfall (Inches)		Net Irrigation (Inches)	
		Normal Year	Dry Year	Normal Year	Dry Year
Crop: Potatoes		Average Growing Season: 5/30 - 9/15			
April	--	--	--	--	--
May	0.12	0.05	0.02	--	--
June	4.74	1.97	1.26	--	0.58
July	8.43	1.55	0.69	6.72	7.74
August	7.75	1.16	0.52	6.59	7.23
September	2.30	0.28	0.13	2.02	2.17
October	--	--	--	--	--
Season	23.24	5.67	4.47	15.57	16.77
Crop: Field Beans		Average Growing Season: 5/30 - 9/15			
April	--	--	--	--	--
May	0.09	0.05	0.02	--	--
June	3.43	1.84	1.20	--	--
July	6.66	1.39	0.60	3.90	5.36
August	7.22	1.14	0.51	6.08	6.71
September	2.35	0.29	0.13	2.06	2.22
October	--	--	--	--	--
Season	19.76	5.37	4.18	12.39	13.58
Crop: Grass		Average Growing Season: 4/15 - 10/15			
April	1.37	0.31	0.15	--	--
May	4.29	1.20	0.60	1.15	1.91
June	6.21	2.15	1.40	4.06	4.81
July	7.76	1.49	0.65	6.27	7.11
August	6.68	1.09	0.47	5.59	6.21
September	3.72	0.62	0.28	3.10	3.44
October	0.99	0.13	0.06	0.86	0.93
Season	31.02	8.14	6.40	20.88	22.62
Crop:		Average Growing Season:			
April					
May					
June					
July					
August					
September					
October					
Season					

TABLE 3.2

ESTIMATED SEASONAL AND MONTHLY CONSUMPTIVE USE

Climatic Area I

Carryover Soil Moisture 3.0" - Net Irrigation Application 3.0"

Month	Consumptive Use (Inches)	Effective Rainfall (Inches)		Net Irrigation (Inches)	
		Normal Year	Dry Year	Normal Year	Dry Year
Crop: Alfalfa		Average Growing Season: 5/1 - 10/8			
April	--	--	--	--	--
May	4.59	1.60	0.90	--	0.69
June	5.95	2.43	1.60	3.52	4.35
July	7.34	2.19	1.26	5.15	6.08
August	6.41	1.48	0.90	4.93	5.51
September	3.53	0.85	0.35	2.68	3.18
October	0.56	0.23	0.08	0.33	0.48
Season	28.38	9.88	7.69	15.50	17.69
Crop: Corn		Average Growing Season: 5/21 - 9/20			
April	--	--	--	--	--
May	1.07	0.48	0.23	--	--
June	4.48	2.26	1.52	--	0.80
July	8.12	2.27	1.30	5.66	6.82
August	7.11	1.66	0.95	5.45	6.16
September	2.43	0.56	0.23	1.87	2.20
October	--	--	--	--	--
Season	23.21	7.97	6.26	12.24	13.95
Crop: Sugar Beets		Average Growing Season: 5/20 - 10/1			
April	--	--	--	--	--
May	0.61	0.44	0.22	--	--
June	3.08	2.10	1.40	--	--
July	8.36	2.28	1.30	4.23	6.13
August	7.81	1.60	0.95	6.21	6.86
September	4.37	0.88	0.38	3.49	3.99
October	--	--	--	--	--
Season	24.23	8.29	6.37	12.94	14.86
Crop: Small Grain		Average Growing Season: 5/1 - 8/8			
April	--	--	--	--	--
May	3.12	1.52	0.81	--	--
June	7.42	2.65	1.77	3.37	4.96
July	7.26	2.15	1.25	5.11	6.01
August	0.81	0.30	0.17	0.55	0.68
September	--	--	--	--	--
October	--	--	--	--	--
Season	18.61	7.25	5.73	8.36	9.88

TABLE 3.2

ESTIMATED SEASONAL AND MONTHLY CONSUMPTIVE USE

Climatic Area I

Carryover Soil Moisture 3.0" - Net Irrigation Application 3.0"

Month	Consumptive Use (Inches)	Effective Rainfall (Inches)		Net Irrigation (Inches)	
		Normal Year	Dry Year	Normal Year	Dry Year
Crop: Potatoes		Average Growing Season: 6/4 - 9/15			
April	--	--	--	--	--
May	--	--	--	--	--
June	3.69	1.92	1.26	--	--
July	7.42	2.20	1.27	3.99	5.58
August	7.25	1.58	0.97	5.67	6.28
September	2.09	0.40	0.19	1.69	1.90
October	--	--	--	--	--
Season	20.45	6.76	5.31	10.69	12.14
Crop: Field Beans		Average Growing Season: 6/4 - 9/15			
April	--	--	--	--	--
May	--	--	--	--	--
June	2.75	1.80	1.19	--	--
July	5.86	2.00	1.13	1.81	3.29
August	6.69	1.51	0.90	5.18	5.79
September	2.17	0.40	0.16	1.77	2.01
October	--	--	--	--	--
Season	17.46	6.38	4.91	8.08	9.55
Crop: Grass		Average Growing Season: 5/1 - 9/30			
April	--	--	--	--	--
May	3.24	1.90	0.81	--	--
June	5.69	2.44	1.60	1.59	3.52
July	7.19	2.17	1.26	5.02	5.93
August	6.12	1.47	0.90	4.65	5.22
September	2.78	0.80	0.34	1.98	2.44
October	--	--	--	--	--
Season	25.02	9.43	7.34	12.59	14.68
Crop:		Average Growing Season:			
April					
May					
June					
July					
August					
September					
October					
Season					

TABLE 3.2

ESTIMATED SEASONAL AND MONTHLY CONSUMPTIVE USE

Climatic Area II

Carryover Soil Moisture 3.0" - Net Irrigation Application 3.0"

Month	Consumptive Use (Inches)	Effective Rainfall (Inches)		Net Irrigation (Inches)	
		Normal Year	Dry Year	Normal Year	Dry Year
Crop: Alfalfa		Average Growing Season: 4/15 - 10/15			
April	1.71	0.63	0.33	--	--
May	5.20	1.92	1.22	1.36	2.36
June	6.42	2.74	1.55	3.68	4.87
July	7.49	2.23	1.37	5.26	6.12
August	6.49	1.94	1.20	4.55	5.29
September	3.77	1.38	0.65	2.39	3.12
October	1.09	0.38	0.10	0.71	0.99
Season	32.17	11.88	9.52	17.29	19.65
Crop: Corn		Average Growing Season: 5/16 - 9/23			
April	--	--	--	--	--
May	1.75	0.81	0.51	--	--
June	5.01	2.52	1.45	0.43	1.80
July	8.21	2.33	1.43	5.88	6.78
August	7.27	2.03	1.28	5.24	5.99
September	2.96	1.02	0.42	1.94	2.54
October	--	--	--	--	--
Season	25.20	9.53	7.64	12.67	14.56
Crop: Sugar Beets		Average Growing Season: 5/15 - 10/1			
April	--	--	--	--	--
May	0.97	0.80	0.48	--	--
June	3.95	2.35	1.35	--	0.09
July	8.77	2.38	1.45	5.16	7.32
August	7.91	2.10	1.33	5.81	6.58
September	4.60	1.44	0.69	3.16	3.91
October	--	--	--	--	--
Season	26.20	9.73	7.86	13.47	15.34
Crop: Small Grain		Average Growing Season: 4/15 - 7/24			
April	2.86	0.69	0.35	--	--
May	5.59	1.97	1.23	2.79	3.87
June	7.86	2.94	1.72	4.92	6.14
July	3.89	1.44	0.86	2.45	3.03
August	--	--	--	--	--
September	--	--	--	--	--
October	--	--	--	--	--
Season	20.20	7.38	5.97	9.82	11.23

TABLE 3.2

ESTIMATED SEASONAL AND MONTHLY CONSUMPTIVE USE

Climatic Area II

Carryover Soil Moisture 3.0" - Net Irrigation Application 3.0"

Month	Consumptive Use (Inches)	Effective Rainfall (Inches)		Net Irrigation (Inches)	
		Normal Year	Dry Year	Normal Year	Dry Year
Crop: Potatoes		Average Growing Season: 5/30 - 9/1			
April	--	--	--	--	--
May	0.12	0.06	0.03	--	--
June	4.79	2.47	1.42	--	0.46
July	8.21	2.32	1.45	5.27	6.76
August	6.70	1.97	1.22	4.73	5.48
September	--	--	--	--	--
October	--	--	--	--	--
Season	19.82	7.30	6.01	9.52	10.81
Crop: Field Beans		Average Growing Season: 5/30 - 9/15			
April	--	--	--	--	--
May	0.09	0.06	0.03	--	--
June	3.38	2.28	1.33	--	--
July	6.30	2.10	1.29	2.33	4.03
August	6.77	1.97	1.22	4.80	5.55
September	2.27	0.66	0.30	1.61	1.97
October	--	--	--	--	--
Season	18.82	7.58	6.19	8.24	9.63
Crop: Grass		Average Growing Season: 4/15 - 10/15			
April	1.28	0.65	0.31	--	--
May	4.17	1.79	1.06	0.01	1.08
June	6.13	2.67	1.53	3.46	4.60
July	7.32	2.21	1.36	5.11	5.96
August	6.27	1.93	1.19	4.34	5.08
September	3.39	1.35	0.65	2.04	2.74
October	0.87	0.33	0.10	0.54	0.77
Season	29.44	11.64	9.33	14.80	17.11
Crop:		Average Growing Season:			
April					
May					
June					
July					
August					
September					
October					
Season					

TABLE 3.2

ESTIMATED SEASONAL AND MONTHLY CONSUMPTIVE USE

Climatic Area III

Carryover Soil Moisture 3.0" - Net Irrigation Application 3.0"

Month	Consumptive Use (Inches)	Effective Rainfall (Inches)		Net Irrigation (Inches)	
		Normal Year	Dry Year	Normal Year	Dry Year
Crop: Alfalfa		Average Growing Season: 5/1 - 10/8			
April	--	--	--	--	--
May	4.84	1.27	0.57	0.57	1.27
June	6.27	2.20	1.28	4.07	4.99
July	7.76	1.80	1.02	5.96	6.74
August	6.77	1.66	0.69	5.11	6.08
September	3.79	0.80	0.33	2.99	3.46
October	0.62	0.12	0.10	0.50	0.52
Season	30.05	8.69	6.80	18.36	20.25
Crop: Corn		Average Growing Season: 5/18 - 9/16			
April	--	--	--	--	--
May	1.45	0.42	0.17	--	--
June	4.94	2.01	1.16	0.96	2.06
July	8.66	1.90	1.05	6.76	7.61
August	7.37	1.76	0.76	5.61	6.61
September	2.09	0.40	0.16	1.69	1.93
October	--	--	--	--	--
Season	24.50	7.02	5.48	14.48	16.02
Crop: Sugar Beets		Average Growing Season: 5/20 - 10/1			
April	--	--	--	--	--
May	0.63	0.35	0.17	--	--
June	3.24	1.86	1.08	--	--
July	8.83	1.90	1.10	5.59	7.35
August	8.26	1.85	0.79	6.41	7.47
September	4.69	0.84	0.35	3.85	4.34
October	--	--	--	--	--
Season	25.65	7.47	5.84	15.18	16.81
Crop: Small Grain		Average Growing Season: 5/1 - 8/8			
April	--	--	--	--	--
May	3.29	1.17	0.53	--	--
June	7.83	2.38	1.44	4.57	6.15
July	7.67	1.79	1.04	5.88	6.63
August	0.68	0.32	0.11	0.36	0.57
September	--	--	--	--	--
October	--	--	--	--	--
Season	19.37	6.31	4.94	10.06	11.43

TABLE 3.2

ESTIMATED SEASONAL AND MONTHLY CONSUMPTIVE USE

Climatic Area III

Carryover Soil Moisture 3.0" - Net Irrigation Application 3.0"

Month	Consumptive Use (Inches)	Effective Rainfall (Inches)		Net Irrigation (Inches)	
		Normal Year	Dry Year	Normal Year	Dry Year
Crop: Potatoes		Average Growing Season: 6/2 - 9/15			
April	--	--	--	--	--
May	--	--	--	--	--
June	4.25	1.84	1.06	--	0.19
July	8.00	1.83	1.03	5.58	6.97
August	7.59	1.76	0.76	5.83	6.83
September	2.24	0.38	0.17	1.86	2.07
October	--	--	--	--	--
Season	22.08	6.21	4.90	12.87	14.18
Crop: Field Beans		Average Growing Season: 6/2 - 9/15			
April	--	--	--	--	--
May	--	--	--	--	--
June	3.12	1.74	1.02	--	--
July	6.35	1.66	0.93	3.07	4.52
August	7.07	1.72	0.73	5.35	6.34
September	2.24	0.38	0.17	1.86	2.07
October	--	--	--	--	--
Season	18.78	5.93	4.63	9.85	11.15
Crop: Grass		Average Growing Season: 5/1 - 10/8			
April	--	--	--	--	--
May	3.41	1.19	0.53	--	--
June	5.92	2.15	1.26	2.99	4.54
July	7.51	1.79	1.03	5.72	6.48
August	6.62	1.65	0.67	4.97	5.95
September	3.32	0.79	0.33	2.53	2.99
October	0.47	0.08	0.03	0.39	0.44
Season	27.25	8.53	6.63	15.72	17.62
Crop:		Average Growing Season:			
April					
May					
June					
July					
August					
September					
October					
Season					

TABLE 3.2

ESTIMATED SEASONAL AND MONTHLY CONSUMPTIVE USE

Climatic Area IV

Carryover Soil Moisture 3.0" - Net Irrigation Application 3.0"

Month	Consumptive Use (Inches)	Effective Rainfall (Inches)		Net Irrigation (Inches)	
		Normal Year	Dry Year	Normal Year	Dry Year
Crop: Alfalfa		Average Growing Season: 4/15 - 10/15			
April	1.77	0.36	0.22	--	--
May	5.35	1.48	0.76	2.28	3.14
June	6.50	2.52	1.65	3.98	4.85
July	7.92	1.76	0.78	6.16	7.14
August	7.29	1.35	0.59	5.94	6.70
September	4.15	0.76	0.33	3.39	3.82
October	1.29	0.17	0.07	1.12	1.22
Season	34.19	9.81	7.63	21.38	23.56
Crop: Corn		Average Growing Season: 5/18 - 9/22			
April	--	--	--	--	--
May	1.51	0.52	0.26	--	--
June	5.00	2.33	1.51	0.66	1.74
July	8.68	1.84	0.79	6.84	7.89
August	7.74	1.37	0.71	6.37	7.03
September	2.94	0.48	0.22	2.46	2.72
October	--	--	--	--	--
Season	25.87	7.43	5.87	15.44	17.00
Crop: Sugar Beets		Average Growing Season: 5/15 - 10/1			
April	--	--	--	--	--
May	0.98	0.63	0.30	--	--
June	4.00	2.20	1.43	--	0.25
July	9.27	1.87	0.83	6.55	8.44
August	8.42	1.42	0.63	7.00	7.79
September	5.05	0.79	0.34	4.26	4.71
October	--	--	--	--	--
Season	27.72	7.91	6.23	16.81	18.49
Crop: Small Grain		Average Growing Season: 4/15 - 7/24			
April	1.00	0.36	0.19	--	--
May	5.84	1.50	0.76	1.98	2.89
June	7.92	2.75	1.83	5.17	6.09
July	4.10	1.12	0.46	2.98	3.64
August	--	--	--	--	--
September	--	--	--	--	--
October	--	--	--	--	--
Season	18.76	6.45	5.06	9.31	10.70

TABLE 3.2

ESTIMATED SEASONAL AND MONTHLY CONSUMPTIVE USE

Climatic Area IV

Carryover Soil Moisture 3.0" - Net Irrigation Application 3.0"

Month	Consumptive Use (Inches)	Effective Rainfall (Inches)		Net Irrigation (Inches)	
		Normal Year	Dry Year	Normal Year	Dry Year
Crop: Potatoes		Average Growing Season: 5/30 - 9/15			
April	--	--	--	--	--
May	0.12	0.06	0.02	--	--
June	4.74	2.29	1.47	--	0.37
July	8.43	1.80	0.80	6.14	7.63
August	7.75	1.35	0.60	6.40	7.15
September	2.30	0.33	0.15	1.97	2.15
October	--	--	--	--	--
Season	23.24	6.59	5.20	13.65	15.04
Crop: Field Beans		Average Growing Season: 5/30 - 9/15			
April	--	--	--	--	--
May	0.09	0.06	0.02	--	--
June	3.43	2.14	1.40	--	--
July	6.66	1.62	0.70	3.36	5.06
August	7.22	1.33	0.59	5.89	6.63
September	2.35	0.34	0.15	2.01	2.20
October	--	--	--	--	--
Season	19.76	6.24	4.86	10.52	11.90
Crop: Grass		Average Growing Season: 4/15 - 10/15			
April	1.37	0.36	0.17	--	--
May	4.29	1.40	0.70	0.90	1.79
June	6.21	2.50	1.63	3.71	4.58
July	7.76	1.73	0.76	6.03	7.00
August	6.68	1.27	0.55	5.41	6.13
September	3.72	0.72	0.33	3.00	3.39
October	0.99	0.15	0.07	0.84	0.92
Season	31.02	9.47	7.44	18.55	20.58
Crop:		Average Growing Season:			
April					
May					
June					
July					
August					
September					
October					
Season					

Daily water use rate. The water use of each crop varies based mainly on species requirements, the stage of plant growth and the daily temperature. Hours of sunlight, humidity and wind generally cause a lesser variation of crop water use.

The daily water use amounts shown in Table 3.3 for the normal irrigated crops are approximations of actual water usage and subject to some error. In using this table for irrigation water scheduling it is important that actual field moisture conditions are checked periodically (usually once a week).

Irrigation systems must have capacity to replace the crop water use during the highest use period to prevent yield reduction. This system capacity can be calculated using the maximum daily water use from Table 3.3 in this formula.

$$\underset{\text{Max. daily water use}}{\_\_\_\_} \text{ in/day} \times \underset{\text{System size}}{\_\_\_\_} \text{ acres} \times \frac{1 \text{ day}}{24 \text{ hrs.}} \times \frac{450 \text{ gal/min}}{1 \text{ ac. inch}} \div \frac{\_\_\_\_\_ \%}{100 \text{ Application efficiency}} = \underset{\text{Capacity}}{\_\_\_\_\_} \text{ gal/min}$$

AVERAGE ALFALFA WATER USE

ALFALFA	Use this chart up to the first cutting and for the fourth and consecutive weeks after cutting.								Use this chart for the first three weeks after cutting ("week" refers to week after cutting).								
Month	May				June	July	Aug.	Sept.	June			July			Aug.		
Week	1	2	3	4	All	All	All	All	1	2	3	1	2	3	1	2	3
Date																	
Temperature 50-59	.04	.04	.05	.06	.09	.09	.08	.07	.06	.07	.09	.06	.07	.09	.05	.06	.08
60-69	.04	.07	.09	.11	.15	.15	.13	.10	.10	.12	.14	.10	.12	.12	.09	.10	.12
70-79	.05	.10	.14	.16	.21	.22	.18	.13	.14	.17	.20	.15	.18	.21	.12	.14	.17
80-89	.06	.12	.17	.19	.25	.26	.22	.17	.17	.20	.24	.17	.21	.25	.15	.18	.21
90-99	.08	.14	.19	.23	.29	.30	.26	.20	.19	.23	.28	.20	.24	.29	.17	.21	.25

AVERAGE SUNFLOWER WATER USE

Week After Emergence	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Date																
Temperature 50-59	.04	.04	.04	.05	.06	.08	.09	.09	.09	.08	.08	.08	.08	.06	.04	.04
60-69	.04	.05	.06	.08	.11	.13	.15	.15	.15	.13	.13	.13	.13	.08	.05	.04
70-79	.05	.07	.09	.12	.15	.19	.22	.22	.22	.18	.18	.18	.18	.11	.07	.04
80-89	.06	.08	.11	.14	.18	.22	.26	.26	.26	.22	.22	.22	.22	.14	.09	.04
90-99	.07	.09	.12	.16	.21	.26	.30	.30	.30	.26	.26	.26	.26	.16	.11	.04

TABLE 3.3

AVERAGE CORN WATER USE

Week After Emergence	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Date																	
Temperature 50-59	.04	.04	.04	.04	.05	.07	.08	.09	.09	.09	.09	.09	.09	.08	.08	.06	.05
60-69	.04	.04	.05	.07	.09	.11	.13	.15	.15	.15	.14	.14	.14	.13	.13	.09	.07
70-79	.04	.05	.07	.10	.12	.15	.19	.22	.22	.22	.20	.20	.20	.18	.17	.11	.09
80-89	.04	.06	.08	.12	.15	.18	.23	.25	.26	.26	.24	.24	.24	.22	.21	.14	.12
90-99	.05	.07	.10	.13	.17	.21	.26	.29	.30	.30	.29	.29	.29	.26	.25	.17	.14

AVERAGE WHEAT WATER USE

Week After Emergence	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Date														
Temperature 50-59	.04	.04	.04	.06	.08	.08	.09	.08	.08	.08	.08	.07	.06	.05
60-69	.04	.04	.07	.10	.13	.14	.15	.15	.15	.15	.14	.13	.09	.08
70-79	.04	.06	.10	.14	.18	.20	.21	.22	.22	.22	.21	.18	.13	.12
80-89	.04	.07	.12	.17	.21	.24	.25	.26	.26	.26	.24	.22	.16	.14
90-99	.05	.09	.14	.19	.24	.27	.29	.30	.30	.30	.28	.25	.19	.17

TABLE 3.3

AVERAGE PINTO BEANS WATER USE

Week After Emergence	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Date														
Temperature 50-59	.04	.04	.04	.04	.05	.05	.06	.08	.09	.08	.08	.08	.08	.06
60-69	.04	.04	.05	.06	.07	.09	.11	.14	.15	.13	.08	.08	.12	.08
70-79	.04	.05	.07	.08	.11	.13	.16	.20	.22	.18	.18	.18	.17	.10
80-89	.05	.07	.08	.10	.13	.16	.19	.23	.26	.22	.22	.22	.21	.14
90-99	.06	.08	.09	.12	.15	.18	.22	.27	.30	.26	.26	.26	.25	.16

AVERAGE SUGAR BEETS WATER USE

Week After Emergence	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Date																				
Temperature 50-59	.04	.04	.04	.04	.05	.05	.06	.07	.08	.09	.09	.08	.08	.08	.08	.07	.07	.07	.07	.07
60-69	.04	.04	.05	.06	.08	.09	.11	.12	.14	.14	.15	.13	.13	.13	.13	.10	.10	.10	.10	.10
70-79	.04	.05	.07	.08	.11	.13	.15	.18	.20	.21	.22	.18	.18	.18	.18	.13	.13	.13	.13	.13
80-89	.05	.06	.08	.10	.13	.15	.18	.21	.23	.25	.26	.22	.22	.22	.22	.17	.17	.17	.17	.17
90-99	.05	.07	.09	.12	.15	.17	.20	.24	.27	.29	.30	.26	.26	.26	.26	.20	.20	.20	.20	.20

Crop Rooting Depths and Irrigation Depths

For most crops the maximum depth of root penetration is comparable to the height of the plant above ground. While not always true, it is a relatively good guide. The most notable exception to this is alfalfa which is a perennial. Grasses, while perennial, are fairly shallow rooted. Where soil conditions are such that there is no restrictive zone to limit root growth, the maximum rooting depths for certain crops are shown in Table 3.4. Moisture extraction patterns for most crops indicate that if adequate water is available, about 70 percent of the water requirement is taken from the top 50 percent of the root depth. Therefore, in an irrigation management program, it is more practical to use an irrigation depth less than the total rooting depth to compute irrigation amounts to add to the soil profile. Irrigation depths for commonly irrigated crops are listed in Table 3.4.

Table 3.4

Crop	Rooting Depth (feet)	Irrigation Depth (feet)
Alfalfa	3-5	4.0
Sugar Beets	2-4	4.0
Corn	4-6	4.0
Field Beans	2-3	2.5
Small Grain	3-4	3.5
Grass	2-3	2.0
Potatoes	2-3	2.0
Sunflowers	3-5	4.0

IRRIGATION AND CROP PRODUCTION

When crop stress from moisture shortage is eliminated by proper and timely irrigation, other factors become inhibitors to production. These factors include poor soil structure and tilth, low fertility, poor stands, weeds, insects and diseases. Much of the water applied through irrigation may be wasted unless sound farming practices are followed.

Soil structure and tilth must be favorable in order to have good aeration, good initial water intake, and good soil permeability. Good soil tilth prevents runoff and water waste. Tilth and structure can be maintained or improved by avoiding cultivation of wet fields, addition of manure or plowing under green manure crops, using grass and legumes in rotation, stubble mulch farming, and minimum tillage. On irrigated pastures, cattle should be excluded until surface soil is dry after irrigation.

Low fertility or an imbalance of nutrients are often the limiting factors on irrigated land. The well-fed plant uses water much more efficiently than a plant that is starved or lacking in some nutrient elements. Total water use by a healthy, well-fed plant is greater than for a plant deprived of plant food, but the production per unit of water is much greater for the well-fed plant. Fertility problems should be corrected by the application of barnyard manure and commercial fertilizer. Soil tests, observations, and field experiences help determine the type and amount of fertilizers to use. Crop quality may be more important than crop production. Quality can be greatly improved by proper fertility or timely irrigations.

Adequate moisture and fertility, and good soil physical conditions will not insure high production unless the irrigation farmer controls pests, uses high quality seed of adapted varieties, and uses timely operations. Weeds, insects, and diseases may be a greater problem on irrigated than on dry land. Crops and varieties should be selected to fit the soil and irrigation system. Plant population should be increased in most cases to take advantage of water added by irrigation.

For maximum production and most efficient use of water, plants must have ample moisture throughout the growing season. This is most important during critical periods of growth and development. Although plants indicate moisture stress by various symptoms, yields will usually be reduced by the time the plant shows stress. Time of irrigation should be determined by examination of the soil for moisture content. Symptoms of serious moisture stress, critical water requirement periods and other irrigation considerations are listed on Table 3.5, Page 3-25.

TABLE 3.5
MOISTURE STRESS SYMPTOMS AND
CRITICAL GROWTH PERIOD FOR IRRIGATED CROPS

CROP	SERIOUS MOISTURE STRESS	CRITICAL GROWTH PERIOD	OTHER CONSIDERATIONS
Alfalfa	Bluish green color, then wilting.	Seedling and immediately after cuttings.	Soil kept moist in upper 4 feet. Avoid over-irrigation. Fall irrigation may be desirable.
Corn	Leaf curl by 10:00 a.m.	Tasseling stage until grain becomes firm.	Sensitive to over-irrigation. Needs adequate moisture from germination to dent stage.
Sugar Beets	Leaves wilting during midday	From seedling stage through root enlargement.	Shallow, frequent irrigation. Avoid over-irrigation, Late fall irrigation lowers amount of sugar.
Small grain	Dull green color, then firing of lower leaves.	Boot, bloom and early head stage.	Irrigate at planting to field capacity. Last irrigation at milk to dough stage. Small grain as a nurse crop, irrigate for needs of grass or alfalfa seedlings.
Potatoes	Darkening of leaves, then wilting.	Tuber swelling period.	Water should not stand around tubers. Do not over-irrigate. Lower tuber quality if plants go into serious moisture stress. Last irrigation 3 to 4 weeks before harvest.
Dry Beans & Soybeans	Dull color, then wilting.	Early bloom, seed forming.	Very sensitive to over-irrigation. Last irrigation at time of first set pod maturity.
Grass Pasture	Dull green color, then wilting.	Seedling stage, for seed production boot to head formation.	Late fall irrigation is necessary. Frequent, light applications. Irrigate at end of grazing period in a rotation system.

CONTROL OF SOIL EROSION

1. Water Erosion

   a. The Irrigation Guide recommendations apply irrigation water at rates that will minimize soil losses from the irrigation application. This is achieved by limiting specified irrigation systems to certain soils and slopes and by the designation of irrigation water application rates, stream sizes, length of runs, and time of irrigation.

   b. The conservation treatment of irrigated lands for erosion from rainstorms is listed in the Technical Guide, Section III.

2. Wind Erosion

   The conservation treatment of irrigated lands for wind erosion is listed in the Technical Guide, Section III.

CONSERVATION TREATMENT SPECIFICATIONS

1. Cropland

   Section IV of the Technical Guide contains specifications of the conservation treatment practices. This will include suggested fertilizer applications for irrigated crops.

2. Pastureland

   Section IV of the Technical Guide contains the specifications of the conservation treatment practices for pasture and hayland crops. Fertilizer applications and the management of these crops for high production are shown.

3. Water Reduction

   Treatment for the control of flooding of irrigated lands and for the reduction of excess ground water conditions is shown in Section IV of the Technical Guide. Practices that will control water problems include but are not limited to:

   Dike and Levee
   Diversion
   Drainage Field Ditch
   Drainage Land Grading
   Drainage Main and Lateral
   Floodway
   Floodwater Diversion
   Pumping Plant for Water Control
   Structure for Water Control
   Subsurface Drain